DEHYDRATED ATLAS SORGO AS A FEED FOR DAIRY CATTLE

by

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INTRODUCTION

The sorghums are of great importance as feed crops in the Central and Southern Plains States and are important feed crops in Kansas. There are about two million acres of sorghum grown annually in the United States with the greatest production in Texas, Oklahoma and Kansas.

Because they are more drought-resistant than corn, sorghums have largely taken its place in this region that sometimes has too little rainfall for corn. An important disadvantage of sorghum is that it depletes soil fertility and does not add nitrogen to the soil as legumes do (Burrill, 1906; Morgan et al. 1938: Madison, 1918).

There has been an increase in alfalfa dehydrating plants in Kansas. The usefulness of these plants has been extended over a larger operating period by dehydrating sorghum forage. This new dehydrated sorghum may have special value as a dairy feed because it is concentrated and can be stored in a small space, and may be another means of handling surplus acres in addition to silo storage. Also, dehydrated sorgo pellets are easily handled and fed without waste. Therefore, dairymen are interested in the feeding value of dehydrated sorghum.

When sorghums are made into silage and fed to dairy cattle, much of the seed passes through undigested (Fitch and Cave, 1932; Atkeson and Beck, 1942). A means of preventing this loss would mean a tremendous saving to the diaryman. In sorgo that is dehydrated and finely ground, the seeds theoretically should be in a

form more readily used by cows.

The purpose of this investigation was to determine the feeding value of dehydrated Atlas sorgo for dairy cattle, by determining its digestibility, its effect on milk production, and other characteristics that affect its usefulness for dairy cattle.

REVIEW OF LITERATURE

Sorghums are highly drought resistant (Compton, 1943; Fitch, 1920; Davis et al. 1943; Hume, 1934; Lyon, 1899; Bechtel et al. 1945) and thus are widely adapted to areas of limited rainfall (Morgan, 1938). The yield of sorgo silage is high compared to corn silage, especially in areas not in the corn belt. Atkinson (1900), in Iowa field experiments, reported yields of 25 tons or more of forage per acre. Cunningham (1927) found that where corn yielded 10.1 tons, sorgo yielded 21.6 tons per acre in Arizona. Hume and Franzke (1934) reported that the average yield of grain from sweet sorghum was 11.6 bushels of grain per acre in South Dakota. However, King (1944) at Purdue found that, although sorgo silage yielded 15.9 tons per acre compared to corn at 11.4 tons, more beef could be produced per acre of corn silage in every case. On the other hand, under adverse weather conditions, sorgo yielded three times as much as corn silage per acre (Lyon, 1899; Martin et al. 1940; McCampbell et al. 1919).

Feeding Value of Sorgo Silage

Sorgo silage varies in composition and feeding value, depending upon its maturity when ensiled, weather, and soil conditions

(Aicher, 1943; Hume et al. 1934; Archibald, 1930). It is considered to have a laxative effect and to give general body tone (King, 1944; Morrison, 1948; Scott, 1916).

Sorgo silage is considered to be of less feeding value than corn silage for milk production, according to Cunningham (1927). La Master (1929) showed sorgo silage as having about 75 percent as much total digestible nutrients as corn silage. According to Morrison (1948), however, sorgo and corn silage are about equal in total digestible nutrients.

Reed and Fitch (1913) found that sorgo silage had only slightly less feeding value than corn silage for dairy cattle. This has been verified by considerable experimental evidence (Burrill, 1906; Cave and Fitch, 1925; Georgeson et al. 1894; King, 1944). Cunningham and Reed (1927) reported data showing that a ton of sorgo silage produced 93 percent as much milk as a ton of corn silage under Arizona conditions. However, under these conditions, sorgo produced much more milk per acre than corn silage because of higher yields.

Feeding Value of Sorgo Fodder

Much of the sorghum grown for forage is fed as dry fodder. Aicher (1943) stated that for feeding native cattle an acre of kafir or cane silage with the heads on was worth from two to two and a half times as much as an acre in the form of dry fodder. Cattle feeding investigations by Anderson (1929) showed that 10.75 pounds of dry matter in cane fodder was worth 8.75 pounds of dry matter

in cane silage. Later work at the Kansas Station indicated that sorgo silage produced about 75 percent more beef cattle gains per acre than whole dry fodder (Call, 1931). Much of this difference was due to waste of the long fodder. Fitch and Cave (1932) found that sorgo fodder and sorgo silage were about equal in feeding value for dairy cattle when fed with hay and grain.

Seath (1930) found that there were no significant differences in milk production between cows fed sorgo silage and dry ground sorgo fodder. Sorgo silage and ground dry sorgo fodder were nearly equal in maintaining body weights of dairy cows.

Additional work on sorghums at the Kansas Station (1932), (1944) showed that sorgo heads could be satisfactorily stored in pits. Sorgo seeds not utilized by dairy cows fed sorgo silage were 10 percent of the feces weight. Seeds voided in the feces were 43 percent of the total seeds present in the feed for Kansas Orange and 36 percent for Atlas.

Feeding Value of Sorgo Seeds

Although the entire sorgo plant is recognized as one of the best for silage, the seed has been regarded by dairymen as unpalatable and as having a tendency to dry up milking cows (Cave and Fitch, 1925). Cave and Fitch later demonstrated, however, that ground sorgo seed was about equal to corn and cob meal as a feed for dairy cows. The ground sorgo seed seemed to have a tendency to increase the butterfat percent in the milk.

Seeds usually represent about 18 percent of the sorghum plant

(Martin and Stephen, 1940). When the plant is made into silage these seeds are not cracked to any great extent. As early as 1902 Otis commented on the large amount of kafir corn that passed through six-month-old experimental beef calves. In 1913 Reed and Fitch reported that as much as 30 percent of the grain of sorgo silage passed through the dairy cow undigested. Fitch and Cave (1925) reported as high as 90 percent of the seeds in Sumac silage were undigested. When they fed kafir silage they found that about 30 percent passed through the animals unused. An increase in the amount of grain fed did not increase the percent of grain recovered from the feces.

The sorghum grain is small and hard and therefore is more likely than some other grains to pass through the cow unmasticated. Any grain in the dairy cow ration that escapes mastication will pass through the digestive tract as whole grain (Atkeson and Beck, 1942). The protective hull of the seed coat must at least be cracked in order to permit digestive juices to act most effectively upon the nutrients in the grain. Observations on the whole sorgo grain that passes through the cow, whether fed as silage or as a concentrate, has caused farmers to inquire about the losses involved, the desirability of grinding the grain, and the degree of fineness to grind it.

Value of Grinding Sorghum Seeds

Becker and Gallup (1927) at Oklahoma found that grinding the cane and grain sorghum seed increased its feeding value from 10

to 25 percent. They recommended heading these crops before ensiling. However, they commented that such a practice depends upon several economic factors such as labor, facilities, and the value of the feed. Other investigators also demonstrated the saving of sorghum seeds by grinding (Koger, 1940; Paterson et al. 1924; Thompson, 1925).

The value of grinding sorgo seeds in silage for beef cattle was investigated by Weber (1938 and 1939). The heads were removed from the fodder at the silo, ground through a hammer-mill and reincorporated with the stover at the feed table. This special silage produced 75.73 pounds of beef per ton. Silage made in the usual manner produced 67.85 pounds of beef per ton. That all the seeds were not wasted in regular silage was demonstrated by the fact that butt (stover) silage produced only 50.39 pounds of beef per ton. Other investigators showed that butt silage (stover silage) was worth about 85 percent as much as regular sorgo silage (Aicher, 1926, 1943; Kuhlman et al. 1932-1934; Bechtel et al. 1941).

Palatability

Most authorities agree that sorghum feeds are usually palatable (Smith, 1927; Cave and Fitch, 1925; Harrington et al. King, 1944; La Master and Morrow, 1929). McCampbell et al. (1919) observed that drought-stunted sorgo silage was much more palatable than drought-stunted corn silage. Anderson et al. found that calves consumed about twice as much cane silage as ground dry cane

fodder. Cave and Fitch (1925) reported that dairy cows relished a grain mix containing kafir about as well as a grain mix containing corn. Cullison (1944) pointed out that cattle preferred urea-treated sorgo silage to regular sorgo silage. Sorgo heads, however, were regarded as unpalatable to cattle (Cave and Fitch, 1925) and were not well liked by poultry (Payne, 1934).

Digestibility

Digestion trials showed that finely ground sorghum grain was more fully utilized by beef cattle (Smith, Parrish, Pickett, 1949) than whole sorghum grain and was somewhat lower in digestibility than corn (Burrill, 1906; Smith, 1930). Morrison's Digestion Coefficients (1948) showed Atlas sorgo silage lower in digestibility than corn silage. Sorghum seed was lower in digestibility of protein, fat and nitrogen-free extract than corn. However, fiber in sorghum seed was 100 percent digestible, compared to 57 percent for corn.

Sugar Content

Investigators found that the sugar content of sorghums varied, but usually was between 13 and 17 percent of the sorghum juice, becoming higher as the plant matured (Cushing and Kiesselback, 1943; Ventre et al. 1948).

Time to Cut for Silage

Lyon (1899) and Franzke (1945) recommended that the best time

to cut sorgo for silage is when the seeds are fairly mature and cannot be crushed between the thumb and finger (Fitch, 1920). Petersen et al. (1910) stated that the dry matter at that time should be not less than 28 percent. Swanson (1929) observed that for some unknown reasons any given variety of sorghums handled under similar conditions, differed from year to year in palatability, feeding value and sugar content.

Effects of Limiting Cows to Sorghum

When the sorghum plant was fed alone it was not a good ration for dairy cows. Cows limited to sorghum showed unthriftiness, night blindness, and lowered milk production (Bechtel et al. 1945; Davis et al. 1943). Deficiencies were probably corrected when cottonseed meal, alfalfa hay, and limestone were included in the rations of dairy cattle (Koger, 1940). Weber (1936) and Cox (1933) found similar results with beef cattle. Alexander (1943) found that sorgo alone was a deficient ration for lambs.

Losses of Nutrients

Losses of feed nutrients when sorghum was ensiled were usually shown to be quite low (Monroe et al. 1946; Burrill, 1906; Archibald and Gunness, 1945). However, when poor silage was made, with excessive heating, dry matter losses were twice as much as normal silage, with heavy destruction of carotene (Reed, 1939; Bechtel et al. 1943).

Dehydration

Dehydration is a relatively recent development in feed processing. Dotterweich (1947) explained the principle of dehydration which essentially is to treat a green-cut crop with a blast of hot air in a revolving drum. The green product then gives off its water, producing a cloud of steam. This steam protects the valuable organic constituents. The quick drying permits retention of high nutrient value.

As far as is known, there has been no published experimental work on the feeding value of dehydrated sorghum. Dehydrated alfalfa and grasses showed high feeding value, however (Barr, 1935; Camburn, 1942; Bechtel et al. 1940; Hodgson, 1932; Newlander, 1932; Snell, 1940). Camburn et al. (1946) found that the dry matter loss from dehydration and storage of grasses was as low as 5.5 percent. Bartlett (1938) and others found that the protein content was high in dehydrated feeds. Palatability was good (Hodgson and Knott, 1932; Hart et al. 1932). Bechtel et al. (1933) and Powell (1935) found that the vitamin D content of dehydrated hay was low. Powell further stated that it may not be safe to feed dehydrated hay to cattle as the only roughage for a long period of time without any pasture. Dairy heifers fed only dehydrated alfalfa from the time they were yearlings until calving nearly all had weak or dead calves, even when exposed to sunlight. Similar results were obtained with rabbits. It was suggested that perhaps some unknown factor had been destroyed by dehydration.

Hauge et al. (1931) found that enzymes play an important

role in the destruction of vitamin A. Mechanical drying with either hot fuel gases or hot air was equally effective in preserving the vitamin A content of alfalfa. High temperatures were shown to be destructive to vitamin A. Conditions favoring enzymatic activity lowered the vitamin A content of alfalfa.

Calcium and phosphorus were found to be as available in dehydrated grasses and legumes as in field-cured grasses and legumes (Hart et al. 1932; Hodgson and Knott, 1933).

Pelleted Dehydrated Forage

Dehydrated forage is frequently compressed to form pellets of various sizes. Advantages claimed for dehydrated pellets are prevention of waste, conservation of nutrients, reduction of storage space, decrease in bulk, elimination of dust, ease of handling, and vitamin preservation (Baker, 1948: Camburn, 1946; Halverson, 1948; Kane, 1947). Mitchell (1949), however, found that while fresh field-cured hay lost 75 percent of its initial carotene, and fresh pellets 20 percent of their carotene, pellets lost carotene more rapidly upon storage because there was more carotene to be lost. The longer the storage the less difference there was. Pellets tended to run a little higher in carotene than powdered dehydrated alfalfa.

Temperatures at which dehydration takes place may influence the digestibility of the dehydrated forage. Hodgson and Knott (1932) reported that grass could be dried at exhaust temperatures up to 350° F. without lowering the digestibility of the forage.

At 400° F. the digestibility of protein was markedly decreased.

Cambum (1942) stated that the application of dehydration to forage may be limited because the high fuel, power, and labor costs of dehydration make it a more expensive process than ensiling. However, Dotterweich (1947) stated that the trend is toward the use of more dehydrated feeds.

Effects of Pelleting and Grinding Roughage

Experimental work by Powell (1938 and 1939) in pelleting feeds is of interest. He reported that a change in the physical composition of the roughage does seem to have a definite influence on the composition of milk, not only in percent butterfat, but also in total solids-not-fat. In these trials "checkers" were made of the feed ingredients by pressing the feed into cubes. In most cases the percent of fat in the milk was lower when "checkers" were fed. One trial showed that checkering was not the only factor, because when the ration was finely cut into short lengths, milk was below normal in butterfat percent. Observation of rumen activity seemed to indicate a correlation between rumen activity and milk composition.

Ingham and De Voe Meade (1929) found also that the average milk fat test was 0.23 percent higher when long hay was fed than when ground hay was fed. In contrast to Powell's results, Espe and Cannon (1945) found no difference in milk fat content when roughage was ground. However, in this trial regular-cut silage was fed in the rations.

Experiments indicated that fine grinding of the roughage had little effect upon its digestibility in cattle (Forbes, 1925; Morrow and La Master, 1929; Olson, 1929; Nevens, 1926 and 1927; Reed and Burnett, 1926; Williams, 1927). Chopping, chaffing, or grinding was found beneficial mostly in reducing wastes and causing consumption of a larger portion of stems (Ingham and De Voe Meade, 1929; Fort Hays, Kansas. Cattle Feeding Investigations, 1931 and 1934; Bohstedt et al. 1930 and 1932; Carlyle and Morton, 1925; Gramlich, 1919; Hayden and Monroe, 1929; Moore and Cowsert, 1926; Nevens, 1927; Vaughn and Harvey, 1929; Reed and Burnett, 1926; Potter and Withycombe, 1926; Weaver et al. 1927; Williams, 1927).

Swanson and Ragsdale (1927) noted that finely ground roughage tended to decrease rumination. Fuller (1928) had observed that normally, cows ruminated about 8 hours in 24 hours. Swanson and Ragsdale (1947) found that dairy heifers nearly ceased ruminating on certain finely ground roughages. There were no significant differences, however, between digestion coefficients of the finely ground and unground roughage. It was concluded that rumination may not be essential to proper digestion of roughage provided that it is ground fine enough not to require remastication. Silver (1940), though, reported that mastication was normal regardless of the method of mechanical processing or the fineness to which the feed was processed. Cattle, on the average, it was found, normally spend from 4 to 11 percent of their time in mastication.

EXPERIMENTAL PROCEDURE

The terms used to describe the feeds are as follows: "Pellets" mean dehydrated Atlas sorgo forage. "Butt silage" is Atlas sorgo stover silage in which the heads were removed before ensiling. "Heads" are ground dehydrated Atlas sorgo tops. "Regular Silage" is Atlas sorgo forage made into silage in the usual manner.

The experiment was divided into 3 phases as follows:

Phase I: The determination of the digestibility of:

1. The dehydrated Atlas sorgo butt silage.
2. The dehydrated Atlas sorgo.
3. The dehydrated heads of Atlas sorgo.

Phase II: A comparison of the feeding value of the following:

1. Dehydrated sorgo pellets.
2. Atlas sorgo heads.
3. Regular Atlas sorgo silage.

Phase III. The effects of Atlas sorgo pellets when fed as the only roughage for lactating dairy cows.

Phase I, Digestion Trial

Purebred yearling Holstein-Friesian, Guernsey, and Jersey heifers were used in the digestion trial. All 15 heifers were raised on the Kansas State College Dairy Farm. The heifers were in good health, in medium flesh, and accustomed to exercise and out-of-doors. Three of the heifers were used for each ration in the digestion trial. Each heifer was maintained on the trial

ration for a period of time sufficient to determine the amount of feed that she would consume before the preliminary period. The preliminary period was 10 days and the collection period was 10 days.

Method of Feeding

Rations for the 15 digestion trial heifers were calculated according to Morrison's Feeding Standards to meet requirements intermediate between maintenance and growth and were adjusted so that a minimum of feed would be refused during the digestion trial. The heifers were fed twice daily at regular hours and were slowly accustomed to their rations before the preliminary period.

All feed used was carefully mixed, weighed, sacked, and labeled before the beginning of the preliminary period to prevent moisture changes from influencing the amount of feed actually fed. Before feeding any previously refused feed was removed from the mangers, weighed, dried, ground and reincorporated with the ration. Water pans were removed from the mangers at feeding time, replaced in the mangers after feeding and given ad libitum.

Preparation and Storage of Rations

The alfalfa hay was chopped in a silage cutter to facilitate weighing, storing, and feeding. The alfalfa hay for each heifer for each feed was weighed and stored in labeled burlap sacks. One small handful was taken at each weighing,

composited and mixed. A sample was then taken from the composite for chemical analysis.

All grain was ground, mixed, and weighed in paper sacks for each feed at the beginning of the preliminary periods. The grain was weighed to the nearest gram and stored in labeled paper sacks. The grain and hay were stored in covered steel barrels. The grain mixture which was also used in the milking trial, was as follows:

400 pounds ground corn
200 pounds wheat bran
100 pounds soybean meal
7 pounds salt
7 pounds steamed bone meal

The ratio of grain to roughage dry matter (1 grain: 2.25 hay equivalent) was the same in all trials.

The Atlas sorgo used for dehydration and for the silages was grown in the same field and as near as possible, the same area in the field. The sorgo was cut with a field chopper and hauled to the C-K Dehydrating Company where it was dried and pressed into one-half inch pellets. The heads were removed from enough sorgo to permit filling a small 10 x 36 foot silo with sorgo butts. Another 10 x 36 foot silo was filled with regular Atlas sorgo from the same field.

Approximately four-fifths of the heads were removed from the butt silage because it was not feasible to remove all of the heads. Some of the heads that were removed from the sorgo plants were ground and dehydrated. These ground heads were reincorporated at each feeding with the butt silage in the original proportion of

heads to butts. This proportion was 70.00 pounds of butt silage to 10.84 pounds of heads.

Collection Period

During the collection period all heifers were under the constant supervision of three attendants who alternated in 4-hour shifts. The heifers were permitted to urinate on the floor. The floor was then washed. As much of the feces as possible was caught from the heifers directly. Feces that dropped on the floor were kept in separate containers and weighed. The aliquot sample that was taken daily for chemical analysis was taken only from the feces caught directly. Daily aliquots were dried immediately in the oven located in the nutrition barn of the Department of Animal Husbandry. Dried feces aliquots were ground, mixed, and analyzed chemically. Digestion coefficients were determined for the following rations:

1. Alfalfa hay and grain concentrate (basic).
2. Alfalfa hay, grain, and dehydrated sorgo (digestion of dehydrated sorgo determined by difference).
3. Alfalfa hay, grain, and sorgo butt silage (digestion of sorgo butt silage determined by difference).
4. Alfalfa hay, grain, sorgo butt silage and dehydrated sorgo heads (digestion of sorgo heads determined by difference).
5. Alfalfa hay, grain, and sorgo silage (sorgo silage determined by difference).

Phase II Milking Trial

This phase of the experiment was designed to compare the feeding value of dehydrated Atlas sorgo with sorgo silage and sorgo butt silage plus dehydrated heads in the rations of dairy cows.

Experimental Animals

Eighteen cows were fitted into a 3 x 3 Latin square design described by Cochran et al. (1941). Three Holsteins, 3 Guernseys, 6 Jerseys and 6 Ayrshires were used. The cows within each group, 1, 2, 3, etc., were as much alike as possible in stage of lactation, age, milk yield and body weight. An attempt was made to use cows free from mastitis and other diseases. The design permits between-group variation, thus there was a variation in stage of lactation between groups.

The grain mixture was the same as described for phase I.

The place of each cow in the design was determined by random number tables. Cows used and fitted by random to the design are shown in Appendix Table 9.

Detailed Design

The detailed experimental design was as follows:

Experimental period	Sets of cows 1 2 3	Sets of cows 4 5 6	Sets of cows 7 8 9
	Rations		
I Nov. 26 to Dec. 30	A* B** C***	A B C	A B C
II Dec. 31 to Feb. 3	B C A	C A B	B C A
III Feb. 3 to March 10	C A B	B C A	C A B

Plan of Feeding and Sampling

Rations for the 18 cows were planned to meet maximum requirements according to Morrison's Feeding Standards. Protein was furnished slightly in excess of requirements according to the standards.

Cows were fed twice daily. All feed was weighed to the nearest one-tenth pound at the afternoon feeding. One handful of each feed was added each day to a composite sample. Each week the sample was mixed and a one-half pound sample was taken from the composite. These weekly samples were composited and analyzed chemically at the end of each 35 day period. Silage samples were frozen immediately after sampling. Hay, grain, and dehydrated sorgo heads were covered and refrigerated until they were analyzed.

Refused feed was weighed back each day, recorded, and subtracted from feed fed to determine feed intake.

Seeds were counted each week from a 25 gram sample of sorgo butt silage and regular sorgo silage to determine approximately the proportion of seeds in each kind of silage.

Records

All feed weights were recorded.

Each cow was weighed on three consecutive days at the beginning of the experiment and at the end of each 35-day trial. The average weight obtained in the three weighings was used as a guide in calculating maintenance requirements for the ensuing period, and as a basis for evaluating the nutrient worth of the ration.

Daily milk weights were recorded and milk was sampled for butterfat test at 10 day intervals. The yield of four percent fat-corrected milk was calculated and recorded.

Observations on physical appearance and behavior of the cows were recorded. Clinical history during the experiment was included. These notes on observations are recorded in the appendix.

Management

The 18 cows used in the experiment were housed in the northeast section of the Kansas State College Dairy Barn. Shavings were used as bedding to prevent cows from eating their bedding. Mangers were boarded up to prevent exchange or loss of feed. Drinking cups were provided. Sore feet were relieved

by burlap mats. The cows were exercised about two hours daily in a vacant lot on all except stormy days. Each cow was groomed daily. All cows were milked twice daily using fast milking procedure and hand stripping. All necessary veterinary treatment was administered by and at the discretion of the college veterinarian assigned to the dairy herd. Periodic examinations were made for mastitis. Salt blocks were provided in the mangers and in the exercise lot.

Phase III

Effects of Limiting the Roughage of the Ration to Dehydrated Sorgo

The purpose of phase III was to determine the effects in lactating cows of limiting the roughage portion of the ration to dehydrated sorgo pellets.

Three Holstein cows were used. Two cows were fed sorgo pellets ad libitum to determine how much would be consumed and to determine the effects of large consumption of pellets. The third cow was limited to normal roughage consumption with the entire roughage composed of sorgo pellets. The ration was balanced by adjusting the concentrate mix according to requirements of Morrison's Feeding Standards.

Observations were made daily. Two continuous observations were made for 48 hours each to determine rumen activity, belching, time spent eating, and other habits. Examinations for rumen activity were made by Kansas State College veterinarians.

EXPERIMENTAL RESULTS AND DISCUSSION

The presentation and discussion of experimental results will be divided as follows:

1. Digestibility.

2. Feeding trials.

3. Ration limited to dehydrated sorgo as the only roughage.

The results of the Digestion Trial (Phase I) are summarized in Table 1.

Table 1. Apparent digestibility of sorgo products[1].

Feedstuff	Total dry matter	Protein	Crude fiber	Ether extract	N.F.E.
	Percent				
Dehydrated Atlas Sorgo Pellets	60.39	29.05	43.32	61.22	73.97
Atlas Sorgo Silage	53.35	26.70	56.92	59.74	56.60
Atlas Sorgo Butt Silage	57.15	39.47	59.28	75.78	59.28
Dehydrated Atlas Sorgo Heads	84.64	77.37	37.30	71.60	90.46
Butts and Heads	65.61	54.77	58.39	79.40	72.50
Basal* (Hay and grain mixture)	67.40	74.62	46.34	55.18	78.15

1/Digestibility of the basal* ration of hay and grain was determined. Each of the experimental feeds was then added to the basal ration and digestibility determined. The difference between the basal and the experimental feed (such as pellets) plus the basal determined the digestibility of the experimental feed.

The digestion coefficients may be somewhat higher than they would be in regular feeding because the rations were limited in the digestion trial so that all the feed was consumed. According to Maynard (1937) an increase in feed intake tends to decrease the

digestibility of all nutrients.

Protein Digestibility. It is interesting to note that the sorgo butts and heads combined were 55 percent digestible and the sorgo pellets and sorgo silage were only 29 percent and 27 percent digestible, respectively. It is difficult to explain this difference. The results of other digestion trials given in Table 2 show that the digestibility of protein of the Atlas sorgo silage agrees with Schneider's (1947) data. However, the digestibility obtained on the butt silage agrees more closely with Morrison's tables. It is interesting to note that Bechtel's (1942) studies showed comparatively low protein digestibility of brown silage. It is also noted that the protein digestibility of the dehydrated sorgo pellets was similar to that reported by Schneider (1947) for Atlas sorgo silage.

Table 2. Comparison of digestion coefficients for Atlas sorgo silage.

	No. of trials	Protein	Crude fiber	Ether extract	N.F.E.	Dry matter
Morrison	2	55	68	55	71	
Schneider	6	27	50	52	68	
Present study		26	56.92	59.74	56.6	53.35
Normal sorgo silage*			58	55	71	64

*Studies by Bechtel et al. (1942).

Crude Fiber Digestibility. The digestibility of crude fiber in the sorgo pellets (43 percent) was considerably lower than that of either type of silage (Table 1). It is interesting to observe

that the sorgo pellets contained 24 percent sugar whereas the amount of sugar in the silages was almost nil. It is possible that the difference in digestibility of fiber may be due to the fact that rumen symbiotic microorganisms use the readily available sugar in preference to fiber for their energy needs in the case of the pellets, whereas in the silages the sugars are converted to acids and are not as readily used. Therefore, the microorganisms attack the crude fiber more readily. Maynard (1936) stated that it has been shown that the addition of easily digestible carbonhydrates such as cane sugar or molasses to a ration of cattle reduced the digestibility of the fiber. This observation has been explained on the basis that the bacteria attack the simpler carbohydrate by preference. A shift in substance attacked, it was explained, would lower the nutritive value of the entire carbohydrate portion of the ration in that less crude fiber would be digested and more absorbable sugar would be lost as gases. Also, differences in crude-fiber digestibility have an influence on the digestibility of all nutrients because intact fiber hinders the action of digesting enzymes on the other nutrients. Maynard further stated that ruminants are able to digest at least 50 percent of the crude fiber of most feeds. If this assumption is valid, it may be contended that the high percentage of sugar in the dehydrated sorgo actually lowers its feeding value.

Ether Extract Digestibility. The digestibility of ether extract was variable. This is to be expected, because digestion

coefficients usually vary, especially in low-fat feeds such as sorgo silages (less than one percent fat). Differences may be due to individual animal differences in fat digestibility and in excretion of metabollic fat.

These differences have not been extensively studied, according to Maynard (1937). However, Fraps and Rather (1912) found that the saponifiable ether extract of 18 different roughages varied in digestibility from 8.6 percent to 92.3 percent.

Nitrogen-Free Extract Digestibility. The digestibility of nitrogen free extract was highest in rations where the sorgo seeds were ground (Table 1). It is also important to note that the digestion coefficient was high for the ground heads. The low digestibility of the regular sorgo silage (57 percent) compared to the high digestibility of the dehydrated sorgo pellets (74 percent) and the sorgo butt silage plus heads (73 percent) can be explained by the fact that the sorgo seeds were not ground in the regular sorgo silage and therefore, digestive juices did not readily attack the nitrogen free extract of the unground seeds. The unground seeds have less surface exposed to digestive action and the hard coating of the sorgo silage seeds may not be readily permeable to digestive juices.

Also, the wax of the sorgo seed may be possibly of some minor importance in digestibility. Cushing and Kiesselback (1945) reported differences in wax content of sorghums. Seeds of most forage sorgo varieties were found to be high in wax content. According to Maynard (1937) and Hawk (1944) waxes are not readily

saponified. Hawk further stated that waxes are not attacked by lipase. Grinding may be of further value in removing some of the wax so that more surface of the seeds are then exposed to digestive juices and enzymatic activity.

Total Dry Matter. The coefficients of digestibility of dry matter (Table 1) are in favor of the sorgo butts plus ground heads (65.61 percent) compared to regular sorgo silage (53.35 percent) and sorgo pellets (60.39 percent). These differences can be explained again, by the contention that grinding the seeds increased the digestibility of the dry matter of the seeds. The sorgo butts plus heads ration was higher in digestibility of dry matter than the sorgo pellets were. This was true because the crude fiber and ether extract digestibility were lower for the pellets.

These digestion trial results are in close agreement with those obtained by Smith et al. (1949). They showed higher digestibility of beef steer rations that included finely ground milo with Atlas sorgo silage than those that included unground milo with Atlas sorgo silage.

Digestible Protein and Total Digestible Nutrients. The digestible protein and total digestible nutrients of the feeds used were calculated on the basis of chemical analysis (Appendix Table 6) and digestion coefficients (Table 1) obtained in the digestion trial. The digestible protein and total digestible nutrients were calculated on the dry matter basis. Digestible

protein and total digestible nutrients were calculated on the combined sorgo butt silage and dehydrated heads as substituted for regular Atlas sorgo in the feeding trial in the original proportion of heads to butts. This proportion was 17 percent heads and 83 percent butts (dry basis).

The results of digestibility and feeding value of the butt silage plus heads may be somewhat erroneous, due to the fact that ground sorgo heads were reincorporated with the butt silage at this rate (17 percent heads and 83 percent butts) without taking into consideration the fact that not all of the heads were removed when the butt silage was made. Seed counts, taken from weekly samples of butt silage and regular sorgo silage revealed that approximately one-fifth of the seeds still remained in the butt silage. These remaining seeds may have been sufficient to give preserving and feeding qualities that pure butt silage might not have. Also, because the dehydrated heads were reincorporated on the basis of original heads to butts, ignoring the fact that some seeds were present in the butt silage, the actual seed proportion of the butt silage plus heads was higher than that of the pellets or regular silage. Percentages of digestible protein and total digestible nutrients are shown in Table 3.

It is interesting to note that the digestible protein on the dry matter basis was about the same for the sorgo pellets (1.89) as for the regular silage (1.87), but was considerably higher for the sorgo butts plus heads (2.77, 4.02, 3.80). This can partly be explained by the contention that grinding increased

Table 3. Percent digestible protein and total digestible nutrients of experimental feeds.

Feedstuffs	Period	Digestible protein	Total digestible nutrients	Dry matter	Digestible protein dry matter (basis)	Total digestible dry matter (basis)
				Percent		
Dehydrated sorgo pellets	I	2.72	55.48	90.82	1.89	61.48
	II	"	"	"	"	"
	III	"	"	"	"	"
Dehydrated sorgo heads	I	7.69	76.01	89.11	8.63	85.30
	II	7.35	75.84	90.32	8.14	83.97
	III	6.77	74.85	89.90	7.53	83.26
Sorgo butt silage	I	0.22	13.82	26.70	0.82	51.76
	II	0.54	12.90	26.5	2.08	48.68
	III	0.52	14.20	25.6	2.17	55.47
Atlas sorgo silage	I	0.57	15.91	30.50	1.87	52.16
	II	0.56	15.63	30.00	1.87	52.10
	III	0.56	16.40	31.20	1.79	52.56
Sorgo butt silage *dehydrated sorgo heads (in original proportion)	I	0.83	17.78	29.91	2.77	59.45
	II	1.24	18.44	30.83	4.02	59.81
	III	1.21	21.16	31.81	3.80	66.51

the digestibility of the seeds. The digestible protein of the butts plus heads was high because of high coefficients of digestibility of the protein of the butts and heads, rather than their crude protein content which was relatively low (pellets, 6.94 percent; regular silage, 6.93 percent; butts and heads, 5.13 percent dry matter basis).

Table 3 shows that the total digestible nutrients of the regular silage were lower than the total digestible nutrients of the pellets or butt silage plus heads. This again can be explained by that contention that grinding the seeds of the pellets and butt silage plus heads increased their digestibility. Considerably more unground seeds were observed in the feces of the digestion trial heifers that received regular silage than those of the heifers that received sorgo butt silage plus heads or sorgo pellets.

Feeding Trial (Phase II)

The results of feeding the 18 milking cows sorgo pellets, sorgo butt silage plus heads, and Atlas sorgo silage will be discussed in this section.

Nutrient Consumption. At the beginning of each period, rations were calculated on the basis of Morrison's (1948) upper limits for total digestible nutrients for maintenance and milk production, substituting sorgo pellets in one ration and sorgo butt silage and ground heads in another ration for Atlas sorgo silage on the dry matter basis.

The total digestible nutrients and digestible protein consumed were calculated on the basis of chemical analysis and digestion coefficients for each cow for each period. The results are given in Table 9 in the appendix. A summary of the total digestible nutrient consumption is presented in Table 4.

Total digestible nutrient consumption was higher for the sorgo butt silage ration (9762 pounds) than for the Atlas sorgo silage ration (9012 pounds) or the sorgo pellet ration (9282 pounds). The highest nutrient consumption of the sorgo butt silage ration can again be explained by its higher digestibility due to grinding and reincorporating the ground heads.

Total digestible nutrient intake compared to Morrison's requirements showed that the sorgo pellet ration was just meeting requirements (100.3 percent). The sorgo butt silage ration exceeded requirements (103.3 percent) but the Atlas sorgo silage ration did not meet requirements (94.2 percent). This information is shown graphically in Fig. 1.

Palatability of Feeds. It was observed that some cows did not readily consume the sorgo pellets at first, but once the cows were accustomed to the pellets, they ate the pellets readily. In fact, some cows, when they had equal choice, preferred the sorgo pellets to grain. Only one cow, 363A, refused to eat dehydrated sorgo in the pellet form. However, when the pellets were ground and mixed with the grain and hay they were readily consumed.

Comparative palatibility of the feeds is indicated by the

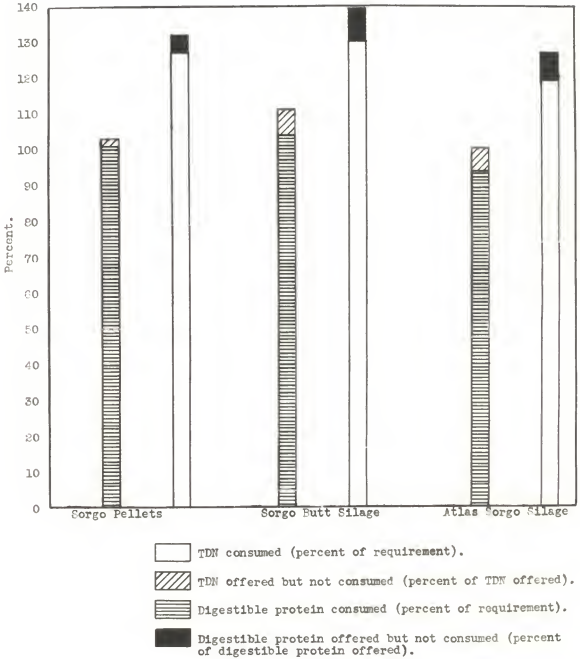

Fig. 1 Relative nutrient consumption of sorgo pellets, sorgo butt silage, and Atlas sorgo silage.

amount of feed refused as is shown in Table 4. and in Fig. 1., which indicate considerably less feed refusal when the sorgo pellets were fed. It was noted that cows especially refused less hay stems when they were fed the ration containing sorgo pellets. This seems to indicate the possibility of larger feed consumption when sorgo pellets are included in the ration than when sorgo silage is fed.

Feed refusal was largest when the cows were fed sorgo butt silage and ground heads, especially early in the experiment shortly after the silos were opened. There was considerably more heating of the butt silage than of the Atlas sorgo silage. Also, when butt silage samples and regular silage samples were stored in covered containers at room temperature for one week, there was considerable molded silage in the butt silage, but no mold in the Atlas sorgo silage. These differences are difficult to explain. The chemical analyses of the silages showed similar pH values (butt silage, pH 4.0, sorgo silage, pH 3.96). The regular sorgo silage was heavier than the butt silage and thus was more compacted in the silo. The regular silage was also higher in carbohydrates. Although both silages were low in sugar, the regular silage was higher (0.62 percent) than the butt silage (0.24 percent). These differences may account for the differences in keeping qualities of the silages.

Physical Effect of the Feeds in the Digestive Tracts. The experimental cows seemed to have more trouble with impaction than

usual, regardless of the type of ration fed. It is believed that the chopped hay plus other chopped or ground feeds in the rations may be responsible for the impaction difficulties, although experimental results with chopped hay have not given such indications (Bohstedt, 1930, 1948; Hayden, 1929; Nevens, 1927). However, fine grinding of hay has been shown to decrease its digestibility (Forbes et al. 1925).

Difficulty with vomiting occurred in the case of 459A when she was fed sorgo butt silage and ground dehydrated heads. During the following period when sorgo pellets replaced the butt silage and heads there was no more difficulty with vomiting. During the transition period 459A was mistakenly fed sorgo butts and heads instead of sorgo pellets. The afternoon of the following day she again vomited.

There was no apparent difference in the rations in laxative effect as observed by the composition of the feces. Apparently the succulent silages were no more laxative than were the dry sorgo pellets.

Milk Production. All milk was weighed, recorded and converted to 4 percent fat-corrected milk (pounds milk x 0.4 pounds fat x 15). Efficiency of milk production is summarized in Table 4.

The average production of fat-corrected milk is shown in Table 4 and in Fig. 2.

Production trends are shown graphically in Appendix Figs. 1, 2, and 3. Declines in production followed the same order as average milk production, but were larger than average daily

Table 4. Comparative values of dehydrated Atlas sorgo pellets, Atlas sorgo butt silage plus heads, and Atlas sorgo silage.

Items compared	Dehydrated sorgo pellets	Sorgo butt silage & heads	Atlas sorgo silage
Milk production (4 percent FCM)*			
Average per cow per day (pounds)	28.6	28.5	27.9
30 day decline total (pounds)	16.8	36.3	63.9
30 day decline (Percent)	3.1	6.6	11.3
30 day decline per cow (pounds)	0.93	2.02	3.55
Liveweight, 30 day period changes			
Average weight per cow	961	971	970
Total gain or loss (18 cows) pounds	-262	+35	-104
Gain or loss per cow (pounds)	-14.6	+1.9	-5.8
Gain or loss (percent)	-1.5	+0.2	-0.6
Total digestible nutrients consumed (pounds)	9282.0	97.62.0	9012.0
TDN intake, percent of requirements	100.3	103.3	94.2
Feed refused (18 cows) pounds	172.6	698.3	555.9
Average feed refused per cow per day, pounds	0.33	1.29	1.03
TDN consumed per 100 pounds. 4 percent FCM	59.3	63.0	59.7
Pounds 4 percent FCM per pound of TDN	1.69	1.59	1.67
Digestible protein consumed per 100 pounds FCM	9.00	9.66	9.32
Pounds 4 percent FCM per pound D. protein	11.1	10.03	10.73
Relative milk production	102.5	102.2	100.0

*FCM is fat-corrected-milk.

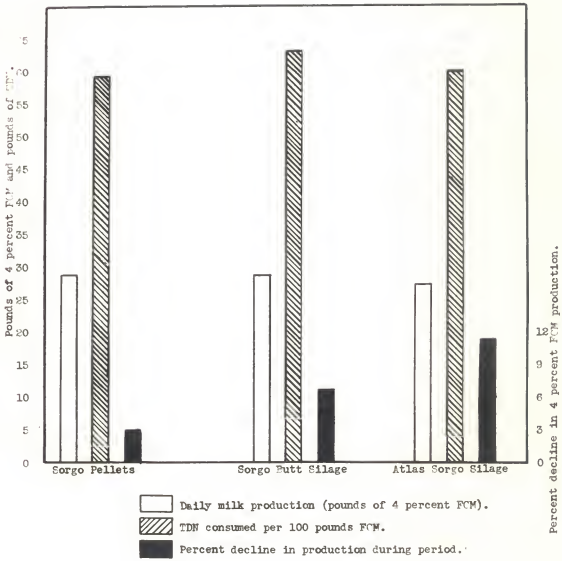

Fig. 2 Relative production of 4 percent fat corrected milk from sorgo pellet, sorgo butt silage, and Atlas sorgo silage rations.

production. Although these differences are small, they are all in the same direction and are in favor of the sorgo pellets. It is possible that in a longer milking period these differences would be manifested. Data on yields of 4 percent fat-corrected milk were treated by analysis of variance as shown in Table 5.

Table 5. Analysis of 4 percent fat-corrected-milk production during the sorghum feeding experiment.

Source of variance	Degrees of freedom	Mean square
Total	53	
Periods	2	122939.34***
Groups	5	618784.1 ***
Groups x Periods	10	2276.43 NS
Cows within groups	12	38489.07***
Residual (Ignoring direct)	2	
Direct (Ignoring residual)	2	6508.62 NS
Residual	2	3171.68 NS
Error	2	3171.68 NS

***Highly significant.

The analysis showed that neither the direct nor the residual effect of feeds was statistically significant. The residual effects as estimated directly from the table of observed data were somewhat confusing. From sets two and six (see experimental design, page 18), in period III (BCA and CBA), the residual effect of B seemed to exceed that of C by about 587 pounds. From sets one and five, the residual effect of A exceeded that of B by

about 996 pounds; but from sets three and four of period III the residual effects of C exceeded those of A by about 18 pounds. That is, B is greater than C, C is greater than B, but C is greater than A, which is not logical. Evidently there was considerable cow-within-group variability which overshadowed whatever differences there might have been.

The objects of the 3 x 3 Latin square design of experiments, according to Cochran et al. (1941) are to secure accurate comparisons of the effects of rations and unbiased estimates of experimental errors. The design also makes it possible to adjust for carry-over effects which have usually been ignored in switch-over trials. In short time experiments, such as this sorgo experiment in which the change-over periods are only five days, there is bound to be considerable carry over effects.

A difficulty encountered in the 3 x 3 Latin square design is to secure experimental cows for groups which are nearly alike. Even though cows were selected as nearly alike in stage of lactation, age, weight, and ability to produce, there still probably remained considerable cow-within-group variability. It is possible that the largest portion of the cow-within-group variability was due to inherent differences in production stimulus.

Mastitis. Some of the cow-within-group variability may have been due to mastitis. However, this difference is small, because the cows were selected, as much as possible, that were free from mastitis at the start of the experiment. Mastitis troubles were not extreme and did not seem more severe when any particular

ration was fed. In the case of 150A corrections were made statistically for the drop in milk production which was attributed to mastitis, rather than to the ration. Mastitis records and treatment are given in Appendix Table 12.

Liveweight Changes. Liveweight changes are shown in Table 4, page 33 and Fig. 3, page 38. The 18 cows were weighed on three consecutive days at the beginning of the experiment and at the end of each 30 day period. The average of the three days was used. According to Patterson (1946) variations from weighing errors can be reduced from 0.97 percent for single-day weights to 0.33 percent for 3-day-weight averages. However, Baker (1946) found non-significant differences between one day weights and three day weights of beef calves. In large animals, day-to-day weight changes would be expected to be larger, however.

Table 4 shows the changes in liveweight of the cows when fed each ration. The changes in liveweight are probably of minor importance because there was an average variation of 7.9 pounds from day to day during the three day weighing periods in each cow's weight. However, on a long-time experiment, these weight changes shown in the table may be important and may influence production. As it was, the cows lost the most weight and also produced the most milk when fed sorgo pellets, although the differences were small.

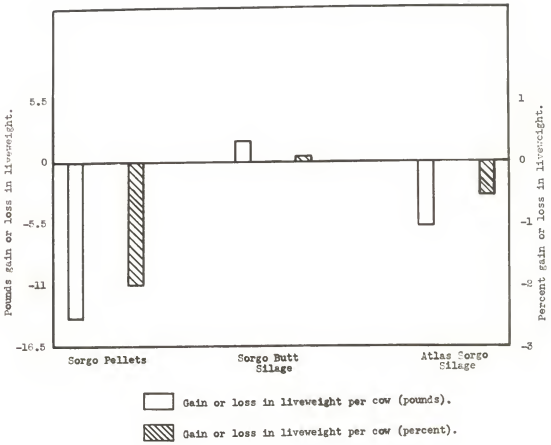

Fig. 3 Liveweight changes of cows when fed sorgo pellets, sorgo butt silage, and regular Atlas sorgo silage.

Effects of Sorgo Pellets as the only Roughage (Phase III)

Two Holstein cows, 134A and 101A were started on a ration of sorgo pellets December 14, 1948. The grain ration was adjusted for protein requirements according to Morrison's Standards. The pellet portion of the ration was rapidly increased. The pellets were very palatable, and after two weeks the cows consumed pellets equivalent to 90 pounds of sorgo silage per day. Then both cows went off feed. Cow 101A decreased in milk from 36.6 pounds to 11.5 pounds milk per day in 20 days. She was removed from the experiment and died January 12, 1949 from hardware in her heart. Cow 134A was returned to alfalfa hay and silage, after which she regained her appetite, "bloom", and normal size to her barrel.

Another Holstein, 127A, was started on a ration of pellets as the only roughage. The pellets were gradually increased to a dry matter equivalent of approximately three pounds of silage and one pound of hay per 100 pounds liveweight daily. A grain ration was calculated to meet the requirements of Morrison's Tables for total digestible nutrients and digestible protein.

This cow seemed to be normal in health when fed only the sorgo pellet plus grain ration. However, she had a distinct craving for long hay. The feces seemed normal, and there was no abnormal drop in milk production.

However, the butterfat test of cow 127A dropped from 3.1 percent in January to 2.3 percent in March. Definite conclusions

as to butterfat decrease should not be drawn from this meager evidence. Powell, (1938, 1939), however, found that cows fed finely ground roughage in the form of "checkers", decreased in butterfat percent of their milk. This contention that finely ground roughage decreases butterfat test has not been widely accepted.

It was observed that all three of the cows when fed sorgo pellets as the only roughage appeared gaunt in appearance with less size to their middles. It appears that the pellets gave less bulk to the ration than long hay and silage. However, when the pellets were soaked in water in a large graduate it was found that they expanded approximately 10 times their volume in 24 hours.

When fed the sorgo pellets as the only roughage, the cows appeared dull in hair coat and lacking in "bloom".

Continuous observations of cow 127A for 48 hours for two different periods a week apart indicated that she ruminated an average of only 52 minutes per day. Normal cows, according to Bergman and Dukes (1942) and Friller (1928) ruminate approximately eight hours in 24 hours, and at frequent intervals. It was observed that 127A ruminated usually for a short while after midnight. It is believed that the physical nature of the ration, probably the fineness of grinding, produced insufficient length of feed particles to form a bolus.

However, Kick et al. (1937) found that cutting hay into short lengths had no marked effect upon the number of chews, time taken for rumination, and number of periods of rumination.

The effects of dehydrated sorgo and other ground and pelleted roughages on rumination needs to be further studied.

Examinations by the college veterinarians showed good rumen tone in 127A when fed pellets. Feces were normal in consistency. Rumen contraction seemed normal. However, the rumen seemed empty to rectal palpations.

A summary of the habits of cow 127A when fed sorgo pellets as the only roughage is given in Appendix Table 13.

SUMMARY AND CONCLUSIONS

Fifteen dairy heifers were used in a digestion trial to determine the digestibility of sorgo pellets, sorgo butt silage plus ground sorgo heads, and Atlas sorgo silage. The results showed slightly higher digestibility of dry matter of sorgo pellets (60.39 percent) than of Atlas sorgo silage (53.35 percent) or sorgo butt silage (57.15 percent). However when ground sorgo heads were reincorporated with sorgo butt silage in its original proportions the digestibility (65.61 percent) was higher than either that of sorgo pellets or regular sorgo silage. It is believed that grinding the seeds accounted for some of these differences.

The protein digestibility showed that the sorgo butts and heads were 55 percent digestible and the sorgo pellets and sorgo silage were respectively only 29 percent and 27 percent, digestible.

The digestibility of crude fiber of the sorgo pellets was lower than that of the silages. It is believed that the lower

than that of the silages. It is believed that the lower crude fiber digestibility was due to their high sugar content (23 percent).

The total digestible nutrients of the regular silage were lower than the total digestible nutrients of the pellets or the butt silage plus heads. This can again be explained by the contention that grinding the seeds of the pellets and butt silage increased their digestibility.

In phase II, a feeding trial was conducted with 18 cows to determine the value of sorgo pellets and sorgo butt silage plus ground sorgo heads compared to regular Atlas sorgo silage for milk production.

The results of the trial showed non significant differences in production of four percent-fat-corrected milk. However, there was less decline in production when sorgo pellets were fed (3.1 percent) than when sorgo butt silage (6.6 percent) or Atlas sorgo silage (11.3 percent), were fed.

Body weight changes were small and probably of minor importance but may show differences in a long time feeding period.

Palatability of the sorgo pellets in general was very high. There was less feed refused when pellets were fed than when the silages were fed.

There was no indication of less laxative effect of sorgo pellets than of sorgo silages. Less rumination (52 minutes daily) occurred when sorgo pellets were fed as the only roughage than is normal (eight hours daily). This effect of sorgo pellets should be further studied.

This investigation is in agreement with previous work which indicated losses of feeding value in the seeds of sorgo silage made in the usual manner.

On the basis of these limited investigations it may be stated that sorgo pellets are about equal to sorgo silage in feeding value for dairy cattle.

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APPENDIX

Table 6. Chemical composition of feeds used in the experiment.

Feeding period	Description of feed sample	Crude protein %	Ether extract %	Crude fiber %	Moisture %	Ash %	N free extract %	Invert sugar %	Carotene mg/100 g	pH
I	Green sorgo fodder chopped	1.88	0.57	5.24	75.52	1.92	14.87		1.61	
I	30-day hay composite	13.94	1.28	33.56	9.02	7.89	34.31			
I	Dehydrated heads 30-day com	9.94	2.19	4.71	10.89	2.58	69.69			
I	Grain mix 30-day composite	16.25	4.24	4.15	12.47	4.89	58.00			
I	Butt silage	1.56	0.61	8.79	73.30		13.37			4.0
I	Atlas silage	2.15	0.72	8.16	69.50		17.21			3.96
I	Atlas silage							0.62		
I	Atlas butt silage							0.24		
I	Dehydrated atlas sorgo pel.	5.94	2.14	19.03	9.18	6.16	57.55	23.59	1.76	
II	Dehydrated atlas sorgo pel.	5.94	2.14	19.03	9.18	6.16	57.55	23.59	1.16	
II	Atlas sorgo silage composite	2.11	.74	7.97	70.00	2.32	16.86			
II	Atlas sorgo butt silage com	1.38	.50	8.71	76.50	2.18	10.72			
II	Grain composite	15.56	4.40	5.22	11.64	4.91	58.27			
II	Dehydrated sorgo heads, com	9.5	3.08	6.94	9.68	3.43	67.37			
II	Hay, composite	14.06	1.40	32.57	9.26	8.16	34.55			
II	Sorgo silage				73.80					
II	Sorgo butt silage				74.60					
II	Sorgo silage				68.00					
II	Sorgo butt silage				76.00					
VI	Grain composite	14.31	3.80	4.77	12.81	5.09	59.22			
III	Dehydrated heads composite	8.75	2.85	6.34	11.10	3.38	67.58			
III	Hay composite	16.88	1.84	24.63	11.77	9.17	35.71			
III	Regular silage composite	2.11	.80	7.83	68.80	2.27	18.19			
III	Butt silage composite	1.33	.52	8.39	74.40	2.17	13.19			
	Composites									
	Grain mix	16.25	4.24	4.15	12.47	4.89	58.00			
	Grain mix	15.56	4.40	5.22	11.64	4.91	58.27			
	Grain mix	14.31	3.80	4.77	12.81	5.09	59.22			

Table 7a. Feed consumption of cows during the 3 experimental periods.

Ear tag number of cows	Feedstuffs											
	Alfalfa hey			Atlas sorgo silage			Sorgo pellets			Sorgo butt silage		
	Periods			Periods			Periods			Periods		
	I	II	III	I	II	III	I	II	III	I	II	III
	Pounds			Pounds			Pounds			Pounds		
300E	182.3	251.1	226.0			651.0		220.0		611.2		
305B	236.1	283.0	279.0		732.0		204.0					
372A	285.1	253.8	275.2		708.0		216.4					667.9
395A	210.0	273.3	284.3	838.2					279.0		642.0	687.0
363A	274.4	263.5	276.8	733.0					186.9		576.0	
470A	265.9	288.0	294.0			804.0		294.0		688.2		
473A	312.0	306.0	324.0		834.0		228.0					801.0
459A	334.1	323.0	306.0	787.8					293.3		596.0	
351A	262.3	290.6	285.6			831.8		278.2		735.8		
249A	319.1	346.1	346.1		852.4				333.8	770.6		
265A	301.7	305.2	274.7	825.5				282.0				680.6
268A	335.1	272.8	324.0		787.7				312.0	809.2		
267A	303.9	275.7	296.7			798.0	222.0				612.0	
248A	267.7	243.6	249.8	762.8				234.8				593.9
245A	358.1	329.2	345.4			966.2	270.0				719.7	
145A	375.1	371.5	365.7			1033.2	268.8				803.4	
150A	364.4	372.0	353.2	1057.1				342.0				878.4
148A	409.0	416.6	417.0		1144.0				399.0	1002.9		
Totals	5396.3	5465.3	5521.4	5004.4	5059.0	5004.2	1409.2	1621.0	1803.9	4617.9	3949.1	4308.8
Totals for 3 periods		16383.0			14117.1			4834.1			12875.8	

Table 7b. Feed consumption of cows during the 3 experimental periods.

Ear tag number of cows	Feedstuffs: Dehydrated sorro heads, Periods I	II	III	Grain, Periods I	II	III
	Pounds			Pounds		
300B	78.1			333.0	336.0	339.0
305B			81.0	294.0	324.0	261.0
372A			81.0	333.0	324.0	255.0
395A		90.0		300.0	264.0	225.0
363A		90.0		354.0	336.0	248.0
470A	90.0			234.0	246.0	231.0
473A			96.0	267.0	222.0	132.0
459A		83.2		267.0	300.0	231.0
351A	96.0			387.0	311.5	258.0
249A	112.7			277.6	234.0	189.0
265A			82.4	264.0	294.0	250.5
268A	102.0			237.0	253.9	246.0
267A		84.0		267.0	263.0	216.0
248A			75.8	276.2	175.7	146.4
245A		102.0		333.0	276.0	204.0
145A		114.0		403.9	384.0	378.0
150A			105.0	549.0	552.0	590.6
148A	132.0			424.0	528.0	456.0
Totals	610.7	563.2	521.2	5850.7	5624.1	4856.1
Totals for 3 periods		1695.1			16330.9	

Table 8. Feed refused as affected by the type of ration fed.

Ear tag number of cows	Feed refused		
	Sorgo pellet ration	Sorgo butt silage ration	Atlas sorgo silage ration
	Pounds		
300B	0.9	76.4	8.0
305B	39.9	23.3	17.0
372A	14.9	5.6	4.2
395A	6.7	26.7	103.8
363A	20.1	0.5	16.9
470A	00.0	41.8	00.0
473A	00.0	0.9	00.0
459A	0.7	16.7	50.1
351A	10.9	57.9	31.6
249A	19.1	149.0	63.3
265A	0.8	40.4	11.2
268A	0.0	9.7	25.0
267A	2.1	1.3	0.3
248A	39.4	100.3	141.1
245A	1.9	31.0	11.0
145A	15.2	1.1	11.0
150A	0.0	10.4	50.9
148A	0.0	105.3	10.5
Totals	172.6	698.3	555.9
Feed refused per cow (lbs.)	10.1	38.8	30.9
Feed refused per cow per day (lbs.)	0.33	1.29	1.03

Table 9. Total digestible nutrient consumption and four percent fat-corrected milk production from sorgo pellet, sorgo butt silage, and atlas sorgo silage rations during the experiment.

Ear tag number of cows	Sorgo pellet ration		Sorgo butt ration		Atlas sorgo silage ration		Digestible protein consumed each period		
	TDN consumed lbs.	FCM consumed lbs.	TDN consumed lbs.	FCM consumed lbs.	TDN consumed lbs.	FCM consumed lbs.	Pellets consumed lbs.	Butts consumed lbs.	Regular consumed lbs.
300B	486.3	899.3	483.0	949.2	456.9	873.3	71.2	77.6	69.9
305B	439.5	846.2	476.5	698.5	485.8	825.3	72.8	72.6	73.1
372B	498.4	917.8	473.2	792.8	467.7	761.6	84.4	71.6	70.1
395A	453.1	603.3	474.9	705.4	446.7	762.9	64.9	70.6	71.3
363A	414.6	679.6	513.0	766.9	500.9	922.2	65.1	78.3	86.2
470A	464.7	733.8	475.5	737.6	439.3	660.9	64.2	76.8	66.4
473A	471.4	775.5	437.9	437.6	440.4	545.6	79.4	64.8	63.1
459A	476.0	766.1	514.1	769.0	477.2	793.5	68.3	79.3	82.7
351A	520.6	785.7	594.5	962.1	458.6	723.7	73.0	97.3	68.8
249A	488.6	629.1	563.2	818.0	471.8	704.5	69.1	91.8	68.9
265A	517.4	823.8	469.9	782.3	464.7	894.1	72.4	71.0	78.3
268A	505.8	726.9	540.3	828.6	439.5	712.6	72.7	88.0	63.6
267A	464.1	751.5	466.9	694.8	429.0	620.5	78.2	70.1	65.0
248A	376.3	582.3	367.0	563.7	446.9	740.9	50.4	55.0	75.2
245A	564.5	908.7	530.3	718.8	471.0	579.2	94.7	79.0	70.1
145A	622.6	1286.0	648.2	1126.8	615.6	1075.8	106.2	98.1	93.3
150A	768.0	1646.9	793.3	1579.1	734.1	1563.4	112.5	122.3	125.3
148A	747.8	1280.5	939.0	1550.2	782.2	1318.8	109.7	132.3	114.5
Totals	9279.5	15643.0	9760.7	15481.4	9008.3	15078.2	1409.2	1496.5	1405.8

Lbs. TDN consumed per lb. FCM	0.593	0.630	0.597
Lbs. FCM per lb. of TDN	1.69	1.59	1.67
D. protein (lbs) per lb. FCM	0.090	0.0966	0.0932
FCM lbs. per lb. D. protein	11.10	10.03	10.73

Table 10. Total digestible nutrients and digestible protein intake in percent of cow's requirement.

Cow's ear tag No.	Total digestible nutrients: Sorgo pellet ration: Daily req. lbs.	Daily intake lbs.	Intake % of requ't	Sorgo butt silage: Daily req. lbs.	Daily intake lbs.	Intake % of requ't	Atlas sorgo silage: Daily req. lbs.	Daily intake lbs.	Intake % requ't	Digestible protein: Sorgo pellet: Da. intake lbs.	Da. requ't lbs.	Sorgo butt: Da. intake lbs.	Da. requ't lbs.	Sorgo silage: Da. intake lbs.	Da. requ't lbs.
300B	15.76	16.2	102.8	16.38	16.1	98.2	15.73	15.2	96.6	2.4	1.98	2.6	2.05	2.3	1.99
305B	15.34	14.7	95.8	15.02	15.9	105.9	16.20	16.2	100.0	2.4	1.86	2.4	1.81	2.4	2.01
372A	17.38	16.6	95.4	14.80	15.8	106.6	16.00	15.6	97.5	2.8	2.15	2.4	1.78	2.3	2.05
395A	14.49	15.1	104.2	15.05	15.8	101.0	17.69	14.9	84.2	2.2	1.70	2.4	1.88	2.4	2.23
363A	14.27	13.8	96.7	16.54	17.1	103.4	17.15	16.7	102.7	2.2	1.73	2.6	2.07	2.9	2.25
470A	14.90	15.5	104.0	14.88	15.9	106.9	14.78	14.6	98.8	2.1	1.73	2.6	1.75	2.2	1.76
473A	15.84	15.7	99.1	13.22	14.6	104.4	15.62	14.7	94.1	2.6	1.81	2.2	1.41	2.1	1.86
459A	15.16	15.9	104.9	17.34	17.1	98.6	17.20	15.9	92.4	2.3	1.79	2.6	1.95	2.8	2.02
351A	17.01	17.4	102.3	19.25	19.8	102.5	15.87	15.3	96.4	2.4	2.07	3.2	2.17	2.3	1.90
249A	15.67	16.3	104.0	17.93	18.3	104.9	17.02	15.8	92.8	2.3	1.80	3.1	2.09	2.3	1.99
265A	16.72	17.2	102.9	16.40	15.7	95.7	17.48	15.5	88.7	2.4	2.02	2.4	1.98	2.6	2.11
268A	16.04	16.9	105.4	16.36	18.0	110.0	16.36	14.7	87.2	2.4	1.90	2.9	2.05	2.1	2.03
267A	15.25	15.5	101.6	14.76	15.6	105.7	14.40	14.3	99.3	2.6	1.18	2.1	1.76	2.2	1.70
248A	14.76	12.5	84.7	13.51	12.2	90.3	17.53	14.9	85.0	1.7	1.72	1.8	1.54	2.5	2.12
245A	18.53	18.8	101.5	17.30	17.7	102.3	15.97	15.7	98.3	3.2	2.23	2.6	2.07	2.3	1.85
145A	22.09	20.8	94.2	20.92	21.6	103.3	21.12	20.5	97.1	3.5	2.73	3.3	2.57	3.1	2.58
150A	25.10	25.6	102.0	26.19	26.4	100.8	26.07	24.5	94.0	3.8	3.15	4.1	3.41	4.2	3.34
148A	24.16	24.9	103.1	28.42	31.3	110.1	26.08	25.4	97.4	3.7	3.01	4.4	3.61	3.8	3.30
Total		309.4	100.3	314.87	325.4	103.3	318.77	300.4	94.2	47.0	37.26	49.7	37.95	46.8	39.12

D. P. intake, percent of requirements:
Sorgo pellet ration = 126.
Sorgo butt silage ration = 131.
Sorgo silage ration = 120.

Table 11. Decline in daily production of four percent fat corrected milk when cows were fed dehydrated Atlas sorgo pellets, sorgo butt silage or Atlas sorgo silage rations.

Cows' ear-tag number	Sorgo pellets: Previous period pounds	Sorgo pellets: Period when fed pellets pounds	Sorgo pellets: Change percent	Sorgo butt silage: Previous period pounds	Sorgo butt silage: Butts period pounds	Sorgo butt silage: Change percent	Sorgo silage: Previous period pounds	Sorgo silage: Regular silage period pounds	Sorgo silage: Change percent
300B	31.3	30.0	4.2	31.3	31.3	0.0	30.0	29.1	-2.7
305B	26.8	28.2	+5.2	27.5	23.3	-15.3	28.2	27.5	-2.5
372B	31.9	30.6	-4.1	25.4	26.4	+3.9	30.6	25.4	-17.0
395A	23.5	20.1	-14.5	25.4	23.5	+7.5	33.0	25.4	-23.0
363A	25.6	22.7	-11.3	30.7	25.6	-16.6	34.9	30.7	-12.0
470A	24.6	24.5	-0.4	23.6	24.6	+4.2	24.5	22.0	-10.2
473A	25.8	25.9	+0.4	18.2	14.6	-19.8	25.9	18.2	-3.9
459A	25.6	25.5	-0.4	26.5	25.6	-3.4	27.6	26.5	-4.0
351A	32.1	26.2	-18.4	31.6	32.1	+1.6	26.2	24.1	-8.0
249A	23.5	21.0	-10.6	27.3	27.3	0.0	27.3	23.5	-14.3
265A	29.8	27.5	-7.7	27.5	26.1	-5.1	31.3	29.8	-4.8
268A	23.8	24.2	+1.7	28.1	27.6	-1.8	27.6	23.8	-14.1
267A	24.8	25.1	+1.2	25.1	23.2	-7.6	23.2	20.7	-10.8
248A	24.7	19.4	+1.7	19.4	18.8	-3.1	30.1	24.7	-17.9
245A	31.2	30.3	-1.7	30.3	24.0	-20.8	24.0	19.3	-22.6
145A	40.5	42.9	+5.9	42.9	37.6	-12.4	37.6	35.9	-4.5
150A	52.1	54.9	+5.4	54.9	52.6	-4.2	52.9	52.1	-1.5
148A	44.0	42.7	-3.0	56.4	51.7	-8.3	51.7	44.0	-14.9
Total	541.5	521.7		552.1	515.9		566.9	502.7	

Percent decline on sorgo pellets, 3.7. Percent decline on sorgo butt silage, 6.6.
Percent decline on sorgo silage, 11.3.
Decline (lbs.) sorgo pellets, 19.8; sorgo butt silage, 36.2; sorgo silage, 64.2.

Table 12. Reports of mastitis examinations and treatments of experimental cows.

Ear tag No. of cow	Date and treatment 11-3-1948	Treatment	12-3-1948	Treatment	1-2-1949	Treatment	2-1-1949	Treatment	3-5-1949	Treatment
300B	A*		C***		A	Mastics 4 days	A	Mastics 5 milkings	A	
305B	A		C	Mastics 4 days	A	Mastics 4 days	C	Mastics 4 days	A	
372B	A		A		A		A	Mastics 5 milkings	A	
395A	A		A		A		A	Mastics 5 milkings	A	
363A	B**		A		A		A	Mastics 5 milkings	A	
470A	A		A		A		A		A	Mastics 5 milkings
473A	A		A		A		A		A	
459A	A	Penicillin in saline 4 da	B	Mastics 4 days	A	Mastics 5 milkings	C	Mastics 5 milkings	C	Mastics 5 milkings
351A	C		C		C		C		C	
249A	C	Penicillin in saline	A		A		A		A	
265A	A		A		A		A	Mastics 4 days	A	
267A	A		A		A		A		A	
248A	A		A		A		A		A	
245A	B		B		A		A		A	
145A	C		A		A		A		A	
150A	A		A		A	Mastics 5 milkings	A	Mastics 5 milkings	C	

*A= No mastitis **B= Staphylococci or high leucocyte count ***C=Streptococci, more than 2 times in succession.

Table 13 Observations of habits of cow 127A when fed sorgo pellets as her only roughage.

Date	Number of times	Total time spent	Average time spent each time
February 12			
Eating	14	79 min.	5.64 min.
Ruminating	3	79 "	26.3 "
Lying down	15	13 hrs. 47 min.	55.0 "
Standing up	14	10 hrs. 13 "	44.0 "
Drinking	5	15 min.	3.0 "
Defecating	10		
Urinating	6		
Milking	2	11 min.	5.5 min.
February 13			
Eating	10	106 min.	10.6 min.
Ruminating	3	51 "	17.0 "
Lying down	15	11 hrs. 6 min.	46.5 " (Not including time getting up, etc.)
Standing up	15	12 hrs. 54 min.	
Drinking	5	10 min.	2.0 min.
Defecating	11		
Urinating	6		
Milking	2	10 min.	5.0 min.
February 26 and 27 (average)			
Eating	10.5	2 hrs. 1 min.	
Ruminating	3.5	38.5 min.	
Ruminating rate	41 chews per minute.		
Lying down	21	11 hrs. 54 min.	
Standing	21	12 hrs.	
Drinking	5	17.5 min.	
Defecating	11.5		
Urinating	6.5		
Belching	26		

Table 14. Three by three Latin-square experimental design.

Period	Group 1 Cow 1	Group 1 Cow 2	Group 1 Cow 3	Group 2 Cow 4	Group 2 Cow 5	Group 2 Cow 6
I	A	B	C	A	B	C
II	B	C	A	C	A	B
III	C	A	B	B	C	A

Period	Group 3 Cow 7	Group 3 Cow 8	Group 3 Cow 9	Group 4 Cow 10	Group 4 Cow 11	Group 4 Cow 12
I	A	B	C	A	B	C
II	B	C	A	C	A	B
III	C	A	B	B	C	A

Period	Group 5 Cow 13	Group 5 Cow 14	Group 5 Cow 15	Group 6 Cow 16	Group 6 Cow 17	Group 6 Cow 18
I	A	B	C	A	B	C
II	B	C	A	C	A	B
III	C	A	B	B	C	A

A=Alfalfa hay, grain, dehydrated sorgo.
B=Alfalfa hay, sorgo silage, grain concentrate.
C=Alfalfa hay, sorgo butt silage, grain sorgo head dehydrated.

Cow	Group	Design No.
473A	I	1
459A	I	2
470A	I	3
267A	II	4
265A	II	5
268A	II	6
372A	III	7
363A	III	8
351A	III	9
145A	IV	10
150A	IV	11
140A	IV	12
305B	V	13
395A	V	14
300B	V	15
245A	VI	16
248A	VI	17
249A	VI	18

EXPERIMENTAL OBSERVATIONS AND NOTES

Sept. 23: Sorgo field inspected for possibilities. Estimate seed yield would be 40 bu. per acre.

Sept. 24: Moisture content of sorgo seeds down to 15.3 percent.

Sept. 25: Percent by wt. heads to total plant: heads equal 17 percent of total.

Oct. 1: Confer with Ag. Engineers on possibilities of mechanical deheaders for making butt silage.

Oct. 3: Ag. Engineering cutter looked at.

Oct. 4: C-K dehydrater inspected. They will donate facilities.

Oct. 5: Heads knocked off in field with corn knives. Drive along side with trailer. Tremendous job to remove heads. Heads saved on rack.

Oct. 6: Rented silos inspected. No roofs may cause snow and rain trouble.

Oct. 7: So much of field sorgo is lodged. Difficult to remove heads.

Oct. 8: Night--sorgo taken to C-K dehydrater. Sacks, strings and equipment taken. Samples taken from loads of fresh-cut forage. Must experiment with heat to find best temperature. Found similar to alfalfa.

Oct. 9: Impossible to make pellets from ground heads. Moisture content must be high to cause sticking. Probably not enough fiber in heads.

Oct. 10: Estimate yield of 25 tons forage per acre or more. Silage seems mature. Some rust in plants. Lower leaves dried and lost.

Oct. 11: All trailers weighed, gross and tare to get silage weight.

Oct. 12: Sixteen and one-fourth tons sorgo yielded 5.9 tons of dehydrated pellets. Pellets have sweet taste like molasses. Pellets to be stored in hay mow.

Oct. 13: Seven-thousand-nine-hundred-fifty heads yielded 5080 pounds dehydrated ground heads.

Oct. 17: Possible animals for milking trial discussed. Mastitis cows discarded. Trios of cows from all cows in herd discussed and grouped tenatively. Milk weights, freshening dates, body weights and health considered.

OBSERVATIONS OF EXPERIMENTAL ANIMALS

Phase 1. (Digestion Trial)

Nov. 13: Digestion trial heifers looked at. Medium condition, long hair, used to outside.

Nov. 14: Heifers confined to 206 barn. Rations calculated. Heifers don't take pellets well at first.

Nov. 15: Some heifers don't get water from bowls. To be repaired.

Nov. 16: Heifers groomed daily. Feces consistency O. K.

Nov. 17: Heifers appear hungry. Holsteins hungry, especially.

Nov. 19: Heifers appear more quiet. Like pellets very well, clean up feed in about 10 minutes after feeding.

Nov. 21: Heifers leave a little feed. Jerseys seem to leave more stems than Holsteins.

Nov. 22: Hot silage--butt silage hotter than regular silage. Silage will be stored over night outside to keep as cool as possible. Silage hauled daily.

Nov. 24: Heifers clean up feed well. Holsteins and Guernseys appear hungry. Hay increased. 45 lb. daily. Grain, 2 lb. on Holsteins and Guernseys--increase hay to grain in nearly same ratio.

Nov. 26: Heifers seem hungry. Poor ventilation in barn. Records in duplicate, checked by 2 different persons.

Nov. 29: Snows and sleet change moisture content of silage even when removed.

Dec. 3: Feces aliquoted at 3 P. M. Chem. Dept. cooperate. Feces well mixed to be sure of representative sample. Feces of good medium consistency. Seems no difference in feces from pellets or silage. Silage still heats. Afternoon silage to be put in large box instead of sacks.

Dec. 4: Sack made for big Holstein heifer that refuses to lie down.

Heifer became stiff. Exercised to prevent as much stiffness as possible. This exercise relieved condition temporarily.

Dec. 5: Sacks made to place under front feet of Holstein heifer. Sacks wired in place.

Dec. 6: Holstein heifer lies down and rests O.K. since sacks placed on floor. All heifers appear hungry and thin.

Dec. 7: Loss of weight of digestion trial heifers is apparent. Heifers seem more contented since radio and heater in barn. Weather turned cold. Men miss less feces in collection.

Dec. 8: Heifers shedding. Groomed daily and kept clean.

Dec. 9: Guernsey heifer has scouring condition.

Dec. 10: Heifers appear to chew on wood. Want to lick metal, etc. to a great extent.

Dec. 11: Weather change--colder. Heifers seem very hungry.

Dec. 12: Floors scrubbed daily. Equipment washed.
First bunch heifers removed. Last bunch moved to trial barn.

Dec. 13: Butt silage and pellet ration has much less seeds in feces than regular silage. First 3 heifers anxious to exercise--to be given long hay.

Dec. 14: Butt silage and regular silage stored in container for one week. Butt silage was very moldy after one week. Regular silage not moldy. First 3 heifers very hungry--take big fill--feed limited.

Dec. 15: Shavings are found in some of feces.

Dec. 16: Little Jersey heifer leaves a few hay stems. Others clean up all of stems.

Dec. 17: Heifers very hungry. Appear thin.

Dec. 18: Last 3 heifers in better condition. Ration slightly more nearly adequate.

Dec. 19: Barn is very damp inside. Ventilation is a problem. Windows left open.

Dec. 20: Some heifers consume much more water. One heifer chews wood on manger.

Dec. 21: One heifer's ration spoiled by mice. Needs reweighing.

Dec. 22: Heifers removed from barn. Anxious for exercise. Taken to 206 barn for adjustment.

Dec. 23: Heifers like long hay. Take large fill. Grain is limited.

Dec. 26: Heifers back to regular winter ration. Consume large amount of hay. Appear to be gaining weight back.

Phase II. (Milking Trial) Observations

Nov. 16: Eighteen mangers to be boarded up to prevent feed loss and exchange.

Nov. 17: Cans gathered (125 lb. lard cans) to store morning rations.

Nov. 19: Cows discussed, observed for trial.

Nov. 24: Quaintness off feed. Watery feces. Hair rough. Body weight and milk production normal. All 18 cows weighed for 3 days. Rations calculated from 3 day average weight. Milk production taken last 10 days.

Nov. 26: Eighteen cows put on trial. Partitions in N.E. large barn put in. Cows placed at random in stanchions. All cows seemingly in good condition. Quaintness O.K. Cows bedded with shavings.

Nov. 27: Cows in dry lot for exercise 2 hours daily. Lot vacant. Cows to have water at all times. First day on feed. Feed changed abruptly. Cows left a lot of chopped hay. Cows didn't clean up pellets well.

Nov. 29: Cows eating pellets better. Sleet and snow change moisture content of silage. Silage to be covered. Silage (especially butts) heats.

Nov. 30: Nosegay off feed (Pellets). Armistice left most of feed (pellets), as did Lullaby (reg. silage), Gala (butt silage) and Brightness (butt silage).

Dec. 1: Cows seem contented. Eating better.

Dec. 2: Gala (butt silage) off feed. Feed cut in half. Several cows have difficulty getting water from cups---to be repaired. Silage, especially butts, gets very hot. Salt block placed in exercise lot.

Dec. 3: Silage to be from silo at noon, weighed and fed soon, to

reduce heating. Afternoon silage to be put in large box instead of sacks to reduce heating. Silage still hot. Cows eat O.K. Look normal. Luster and Nosegay have mastitis.

Dec. 3: Nosegay still has trouble with water cup.

Dec. 6 : Nosegay (Pellets) gets water O.K. Luster (Butts) had bad hay. All refused.

Dec. 7: Brightness (Butts) in heat. Gala (Butts) appetite best since start of experiment.

Dec. 10: Luster (Butts) treated with mastics in 2 quarters, for strep.

Dec. 12: Quaintness (pellets) scouring. Did not eat. Vets to examine.

Dec. 13: Gleam (Pellets) in heat. Quaintness (pellets) still scours.

Dec. 14: Quaintness (pellets) still scours. Down in milk about one-half, eating O.K.--ration cut one-half, feces normal.

Dec. 18: Several cows have colds. Luster (butts) worst.

Dec. 20: Sample of butt silage one week old was musty. Regular silage was O.K.

Dec. 23: Many of the cows have running noses.

Dec. 27: Feces from cows on different rations appear like in consistency. Brightness (butts) in heat.

Dec. 29: Nosegay (pellets) treated with mastics for strep. mastitis.

Jan. 1: Many of cows have running noses. Luster (butts) has rough hair. Cows look thin in general.

Jan. 2: Angeline has been "C" for mastitis--treated with sulphamethazine for staph. mastitis.

Jan. 3: All cows O.K. Several have slightly nasal discharge.

Jan. 6: All cows O.K.

Jan. 8: Nosegay (reg. silage) in heat.

Jan. 10: All cows O.K.

Jan. 12: A test was run on dehydrated pellets by soaking in water. After a few minutes the pellets were 110 percent of original volume. After one day the pellets were 3 times the original volume in size--due to water absorption.

Jan. 13: All cows O.K.

Jan. 14: No apparent difference in feces from different rations.

Jan. 15: All cows O.K.

Jan. 16: Jerseys seem to leave more hay.

Jan. 17: Elegance (reg. silage) never refuses any feed.

Jan. 18: Cows like pellets--eat pellets sometimes in preference to grain. Frolic (pellets) compacted--drenched by vets. Armistice (Reg. silage) feet improved--continued in maternity barn except for milking. Hanna (Reg. silage) drenched by vets for compaction--refuses feed.

Jan. 19: Hanna (butts) drenched again by vets. Condition improving. Frolic (pellets) still compacted--drenched again by vets.

Jan. 20: Cream Puff (pellets) very slick, never has feed weigh back.

Jan. 21: Can't tell over by physical appearance of animals what ration is fed.

Jan. 23: All cows O.K.

Jan. 25: All cows O.K. Hay is better than a month ago.

Jan. 27: All cows O.K. No difference in feces from ration.

Jan. 29: All cows O.K.

Jan. 30: Inabelle (butts) vomits.

Jan. 31: Inabelle (butts) continues vomiting.

Feb. 1: Inabelle (butts) still vomits. Inspected and drenched, by vets. Angeline treated with mastics for mastitis--for 5 milkings.

Feb. 2: Inabelle (butts) not improved. Other cows O.K. Kit (pellets) refuses pellets.

Feb. 3: Inabelle (butts) cut on ration. Butt silage and ground heads cut out. Hay doubled.

Feb. 4: Inabelle (butts) leaves five parts of hay in manger--

likes coarse stems best. Kit (pellets) continues to refuse pellets.

Feb. 6: Gala (pellets) slow to clean up feed. Kit (pellets) refuses pellets. Inabelle (butts) fed butt silage by mistake--ate butts O.K.--looks good.

Feb. 7: Inabelle (pellets) vomited.

Feb. 8: Inabelle (pellets) back to pellets--is O.K.

Feb. 10: All cows O.K. except Kit (pellets)--refuses pellets.

Feb. 12: Kit (pellets) ate a few pellets. Nosegay (butts) treated for mastitis.

Feb. 13: Kit (pellets) treated with mastics for strep. mastitis. Armistice (butts) treated in 1 quarter with mastics. Lullaby (pellets) treated in 2 quarters with mastics.

Feb. 14: Kit (pellets) pellets to be ground and mixed with grain. Kit (pellets)--may be changing (adding) new teeth. Empress (butts) compacted.

Feb. 15: Kit (pellets) eats ground pellets O.K. when mixed with grain. Empress (butts) given epsom salts for compaction.

Feb. 16: Empress (butts) feces hard and dry. Normal in volume.

Feb. 17: All cows apparently normal--Empress (butts) improved.

Feb. 19: Dream (butts) has mastitis. Grain cut one-half at request of vets. Production to be adjusted.

Feb. 20: Luster (reg. silage) scours. Hair coat dull.

Feb. 22: All cows O.K. except Dream (butts). Udder not inflamed, hard or hot.

Feb. 25: All cows O.K. except Kit (pellets) has thin manure. Eats ground pellets O.K.

Feb. 27: All cows O.K. No difference in feces by appearance.

Feb. 29: All cows O.K. Dream (butts) seems better.

Mar. 1: Kit (pellets) eats pellets O.K. when ground.

Mar. 2: No feed eaten by Frolic.

Mar. 3: Inabelle (pellets) given gonodotropin to cause estrus--by vets. Caused anaphylaxis. Eyelids swelled.

Mar. 4: Inabelle (pellets) down in milk. Butterfat test discarded because probably abnormal.

Mar. 5: Inabelle (pellets) appetite O.K. Milk started back up.

Mar. 7: All cows seem O.K. Frolic (butts) back to one-half feed.

Mar. 10: Frolic (butts) has large weigh-back of silage. Not hungry for butt silage. Brightness (pellets) always cleans up all feed. Cows on pellets have less weigh-back than other rations.

Mar. 11: Cows off experiment--take tremendous fill of long hay. Seem to crave long hay.

Mar. 12: Cows take large fill of long hay.

Mar. 15: Several cows down in milk. Eat a lot of hay.

Mar. 30: Cows in general from experiment have gained weight and have gone down in milk.

Phase III. Observations

Dec. 14: Tinkle and Festive to be started on pellets.

Dec. 18: Pellets increased, hay cut down. Two cows eat pellets O.K.

Dec. 20: Ration calculated. Four lbs. milk and give 1 lb. grain. Dig. protein to be 18.4 percent.

Dec. 21: Yolette cleaned up pellets very well. Festive reluctant about pellets at first.

Dec. 22: Ration low in Ca and P. Cows eat pellets O.K.

Dec. 23: Yolette up to 90 lbs. equivalent of silage in pellets daily. Both cows appear to have less middle.

Dec. 26: Yolette off feed. Has small amount of manure. Both cows have less barrel than they should have.

Dec. 27: Festive did not eat all of feed.

Dec. 29: Both cows look thin--decreasing in milk.

Jan. 2: Festive off feed. Did not eat pellets. Given alfalfa hay.

Jan. 4: Both cows have little middles. Have small volume of feces. Look better since hay fed. Hair not so rough.

Jan. 6: Hair gloss coming back. Cows eat O.K.

Jan. 7: Tinkle, wt. 1422, to be started on pellet ration.

Jan. 8: Yolette getting very thin. Taken off pellets. Has been in box stall. Hair coat rough--gets thinner all of time.

Jan. 11: Yolette died--posted. Hardware in heart. Tinkle started started eating pellets. Hay to be reduced gradually.

Jan. 14: Tinkle likes pellets. Middle looks smaller. Feces normal. Milk normal.

Jan. 25: Tinkle on nearly all pellets.

Jan. 26: Tinkle refused to eat all of grain or pellets.

Jan. 28: Tinkle cut on pellets.

Jan. 29: Tinkle eats O.K.

Jan. 31: Tinkle O.K.

Feb. 2: Tinkle left about one-fourth of pellets. Hair coat looks dull. Middle is smaller--looks thin.

Feb. 4: Tinkle looks rough. Holds up O.K. in milk. Craves long hay.

Feb. 6: Tinkle O.K. Feces normal, looks rough hair [illegible].

Feb. 10: Tinkle has distinct craving for long hay. Tries to eat bedding.

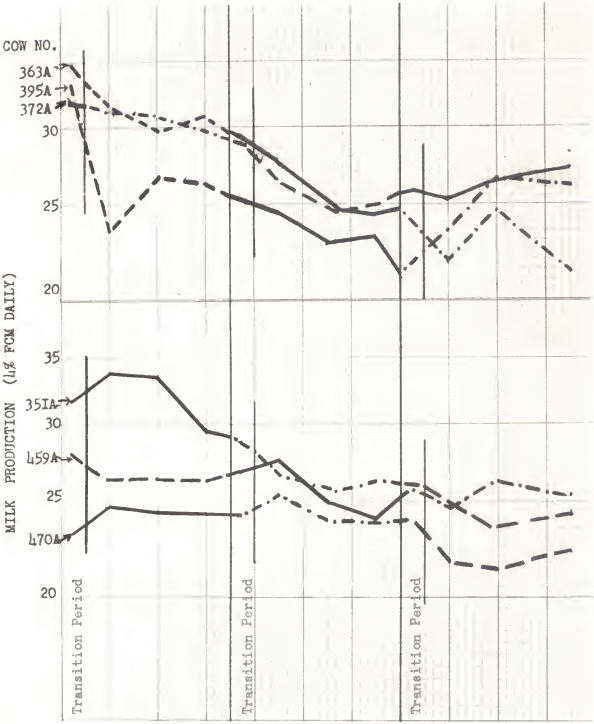
Feb. 12: Observation period; found rumination only 26 min. per 24 hours.

Feb. 14: Tinkle crazy for long hay.

Feb. 15: Rumen palpation given by Dr. Oberst. Has one each 45 seconds (normal). Feces normal in consistency. Rumen seems empty to rectal palpations. Contractions same as in normal cow. Small intestine and colon same as in normal cow. Body weight down from 1422 to 1356 lbs.

Feb. 26: Tinkle chews cud for just short while at night. Belches often. Observations--continuous for 48 hours. Ruminates for only 17 minutes per day. Belches often. Defication normal. Craves long hay--is restless.

Feb. 27: Ruminates only 38.5 minutes per day. Belched 26 times in 24 hours. Chews cud at 41 times per minute.



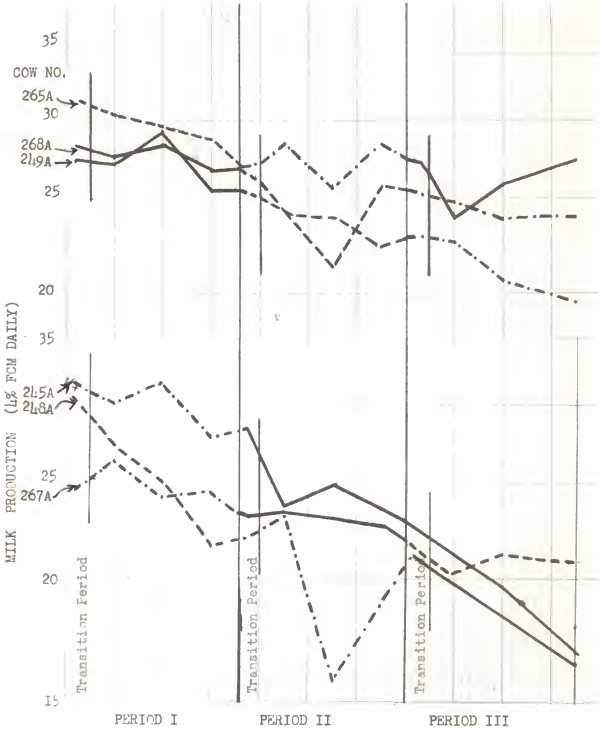
PERIOD I PERIOD II PERIOD III

Ration Containing Sorgo Pellets

Ration Containing Sorgo Butt Silage

Ration Containing Regular Sorgo Silage

Fig. 1 Trends in daily production of four percent fat-corrected milk by periods.



Ration Containing Sorgo Pellets — · — · — ·

Ration Containing Sorgo Butt Silage ————

Ration Containing Regular Sorgo Silage — — — —

Fig. 3 Trends in daily production of four percent fat-corrected milk by periods.